THE U.S. ARMY EXPERIENCE: COLD TOLERANCE AND SEED VIABILITY CHARACTERISTICS OF VETIVER

M. Shariff
U.S. Army Corps of Engineers
Engineer Research Development Center
Construction Engineering Research Laboratory
Champaign, Illinois, USA

Abstract

Three varieties of vetiver *(V. zizanioides), viz.* Sunshine, Louisiana, "Boucard" of Leakey, Texas, and India-origin, were planted at 18 U.S. Army installations during 1990-1996. The results of this research study are presented in this paper. The objective of the study was twofold: investigate and determine the cold tolerance and agronomic characteristics of vetiver under various soil and climatic conditions, and determine the flowering, seed production and seed viability characteristics to avoid potential introduction of another invasive species such as Kudzu *(Pueraria phaseoloides)* into the United States. It was concluded that occasionally a few plants from the entire population of the Sunshine variety may flower and produce mature seed. The results showed that the entire population of India-origin vetiver species flowers profusely and produces mature seed. Seed germination tests conducted under controlled laboratory environment indicated seed viability ranging between 0 and 71 percent for the India-origin and 0 and 15 percent for the Sunshine variety. Nevertheless, field observations have shown that mature and viable seeds would seldom germinate and establish plants. Under actual field conditions, seedlings did not establish and develop to maturity.

The results of cold tolerance and winter hardiness studies showed that vetiver is not cold resistant above latitude 40^{o} N. Vetiver is non-invasive, non-aggressive and does not like competition from native grasses. Erosion and sediment control effectiveness results have shown that the grass performs well on rich, fertile soils in humid regions compared with poor plant establishment in sandy soils.

Introduction

The United States Army operates and manages approximately 12.6 million acres of land to support its combat training mission. U.S. Army land managers are confronted with more difficult training-land maintenance problems than ever before. Greater demands are made on them as force modernization programmes using more mobile weapon systems (Fig. 1) operate over larger areas, resulting in severe land disturbance and soil erosion and sedimentation problems.

Obviously, the candidate grasses selected for erosion control and restoration of critically disturbed U.S. Army lands must possess, among other desirable characteristics, the following minimum attributes:

1. be resilient to tracked and wheeled vehicular traffic,
2. be able to survive under nutrient-deficient, critically disturbed soil conditions (where topsoil has eroded and soil structure is almost completely destroyed) and
3. be capable of plant growth and establishment under natural conditions with no supplemental irrigation water.

Given the level of environmental concern and the prior unpleasant experience with Kudzu *(Pueraria phaseoloides)* – a so-called miracle grass for erosion control from Southeast Asia – the introduction of an exotic plant species is a definite "no-go" in the United States. Though vetiver has been in the country for over 150 years, it is still an unknown plant in the botanical and erosion control community. Vetiver is a tropical grass species that grows well in hot and humid regions of the world. Initial uses involved oil extraction for a small perfume industry and growth for ornamental purposes. As an erosion control measure at U.S. Army lands, the vetiver was first planted at Ft. Polk, Louisiana (LA), in the spring of 1990. The material was obtained from a local retired farmer, Mr. Eugene Le Blanc of Sunshine Village, LA. It was propagated in a greenhouse by USDA Plant Material Center (PMC) researchers at Baton Rouge, LA. Due to the lack of further information, this cultivar of vetiver obtained from Sunshine Village is referred to as the Sunshine variety in this report.

Fig. 1. Mobile weapon land disturbance

Objective

Following the successful results at Ft. Polk, it was decided to expand the field testing to other U.S. Army installations. Since the grass is inherently a tropical plant, it was decided to field-test it in the warm and humid climates of the south and southeast. There is serious environmental concern that must be addressed before its introduction on U.S. Army lands. Therefore the main objectives of this research were to demonstrate that the plant will not become an invasive and uncontrollable weed problem and to document the geographical range for its survival.

Procurement of Parent Material

Search for plant material revealed immediately that vetiver seedlings were not available in desirable quantities for planting at several installations. To meet project requirements, the following sources/vendors were contracted to propagate parent material for field planting at selected sites.

1. USDA, Plant Material Center (PMC), Baton Rouge, LA
2. USDA-PMC, Columbus, Georgia (GA)
3. Eugene Le Blanc, Sunshine, LA
4. Gueric Boucard, Leakey, Texas (TX)

The material obtained from Louisiana was the Sunshine variety. The source of vetiver material obtained from Gueric Boucard of Leakey, TX, could not be ascertained. Vetiver material received from USDA-PMC, Columbus, GA, was propagated from germplasm obtained from India and is designated as the India variety in this paper.

Vetiver Propagation and Field Planting

Vetiver material obtained from Gueric Boucard and Eugene Le Blanc was raised in field nurseries. The seedlings supplied by the USDA-PMC researchers were planted in 6”-diameter nursery pots and grown over winter in heated greenhouses for a period of four to six months. During this time the plants produced four to six healthy tillers (Fig. 2). Vetiver crowns were removed from the pots and the dead portion of the lower roots was cut (Fig. 3) before planting in the field. Pot-grown seedlings were planted four inches deep in rows. Spacing between plants was 12 inches. Two tablets, weighing 21 grams each, of slow-release fertilizer of 20:10:5 (N_2, P_2O_5, K_2O) were placed approximately four inches away from the freshly planted seedlings. No supplemental water was applied after planting.

Table 1 shows where the vetiver cultivars were planted at various locations.

Fig. 2. Vetiver tiller

Fig. 3. Cutting lower roots of tiller

Table 1. Vetiver field demonstration sites

	Site	State	State Abbreviation	Variety
1	A.P. Hill	Virginia	VA	Sunshine
2	Champaign	Illinois	IL	Sunshine
3	Camp McCain	Mississippi	MS	Sunshine
4	Camp Shelby	Mississippi	MS	Sunshine
5	Fort Bragg	North Carolina	NC	India/Sunshine
6	Fort Benning	Georgia	GA	Boucard, TX
7	Fort Campbell	Kentucky	KY	India/Sunshine
8	Fort Chaffee	Arkansas	AR	Sunshine
9	Fort Hood	Texas	TX	Sunshine
10	Fort Leonard Wood	Missouri	MO	Sunshine
11	Fort Polk	Louisiana	LA	Sunshine
12	Fort Sill	Oklahoma	OK	Sunshine
13	Fort Stewart	Georgia	GA	Boucard, TX/India
14	Lubbock	Texas	TX	Sunshine
15	McAlester	Oklahoma	OK	Sunshine
16	Manhattan	Kansas	KS	Sunshine
17	Pine Bluff	Arkansas	AR	Sunshine
18	Red River	Texas	TX	Sunshine

Results

Plant Growth Characteristics

Some 50 000 plant seedlings obtained from Boucard of Leakey, TX, were planted at Ft. Benning, GA, and Ft. Stewart, GA, during June-July 1994. The contractor delivered the field-grown seedlings as single stems. Not a single plant survived at either location. The actual cause of 100-percent mortality could not be ascertained. It seems likely that tender singular stems died during the five to seven days' transit period because of excessive heat stress in confined trucks during hot weather.

The following year, seedlings of the India variety, provided by USDA-PMC Columbus, GA, were planted at several U.S. Army installations including Ft Stewart, GA. Ft Stewart has good soils and abundant rainfall. The plants grew fast and within four months of transplanting started producing flowers. Fearing that they may have another Kudzu at hand, the land managers demanded the destruction of all plants. Efforts to convince them to let some of the plants survive till seed maturity did not succeed.

Though the vetiver did not perform well at several U.S. Army installations during subsequent years, plant establishment was astounding at all locations during the first year of planting. This may be due to fertilizer application at planting time and nutrient deficiency during the following years.

Under greenhouse controlled conditions, the Sunshine variety grown in nutrient rich soil with adequate water exhibited a rooting depth equal to its aboveground height. As shown in Fig. 4, the roots were over three feet long within 12 weeks. At one Ft. Campbell site, the India variety was planted on the banks of a non-perennial stream in a wooded area. The soil at that site was sandy loam very rich in

nutrients. The plants grew over 13 feet (Fig. 5) in just one summer. This substantiates the fact that vetiver is a wetland plant, as indicated by its name *"zizanioides"* or riverside. The number of tillers counted at the site ranged between 17 and 32 erect stems.

Fig. 4. Vetiver roots shown to grow in excess of 3 feet in 12 months

Vetiver planted at sandy loam sites at Ft. Campbell grew over 7 feet tall (Fig. 6) and produced profound clumps during its first year of planting. However, most plants did not survive the cold winter. Over the past five years, some are still surviving but are being taken over by native species.

Fig. 5. Nutrient at Ft. Campbell

Fig. 6. Sandy loam at Ft. Campbell

At the other extreme, India and Sunshine varieties of vetiver were planted in almost pure sandy soils at Ft. Bragg, North Carolina (NC), as shown in Fig. 7. The plant growth was not as robust as those planted at Ft. Campbell. It is encouraging to note that vetiver is the only plant species still surviving while all efforts to establish natives have failed at that site.

Fig. 7. India and Sunshine varieties in sandy loam at Ft. Bragg

At locations where the India variety was planted side-by-side with the Sunshine variety, results show that the India variety grows taller and produces more robust stems. The Sunshine variety grows shorter and produces a bushy plant structure (Fig. 8).

Fig. 8. Sunshine variety planted at US CERL in Champaign, IL

Karyotypics of Vetiver

Dangers and risks of introducing exotic vetiver into an established ecosystem have been ignored or are non-existent in literature. Further research on vetiver indicated that most cultivars do not produce viable seed. If the plant was a triploid and thus sterile, it could be introduced on U.S. Army lands without any environmental concern. Karyotypic testing performed at the University of Illinois showed that both cultivars of India and Sunshine had a chromosome number of $2n = 2x = 20$ (Fig. 9). This confirmed that the plant is diploid and capable of producing mature fertile seed.

Fig. 9. Sunshine diploid chromosomes

Seed Viability and Seed Germination

There is no evidence in the literature that a thorough evaluation of seed production and germination has ever been conducted. Viable seed production is an area of concern. We do not want exotics introduced in the United States that may become invasive to native plant species.

The Ft. Polk experience has shown that the Sunshine variety only flowered occasionally, producing few inflorescences which did not produce mature seed. Nonetheless, when the Sunshine variety was grown at CERL in Champaign, Illinois (IN), and Ft. Bragg, NC, more plants than expected started flowering in late August and produced mature seed. Things were more alarming with the India variety. The entire population flowered at each and every location where it had been planted and produced mature inflorescences as shown in Fig. 10. Flowering of the India variety starts late August and

continues through October. Flowers and seed heads are purple and over two feet long. No birds have been noticed eating the seed and all seed are shed over ground by the time winter arrives.

Mature inflorescences were collected from both Sunshine and India varieties. The seed heads were sent to Purdue University in West Lafayette, Indiana, for testing. The number of seeds for inflorescence was counted and approximately 400 seeds were selected for seed germination under controlled laboratory environment. Seed numbering and germination test data are given in Figs. 11 and 12 and Appendices A and B. Appendix C shows the number of seeds tested over a four-week period and the number of seeds germinated during each week.

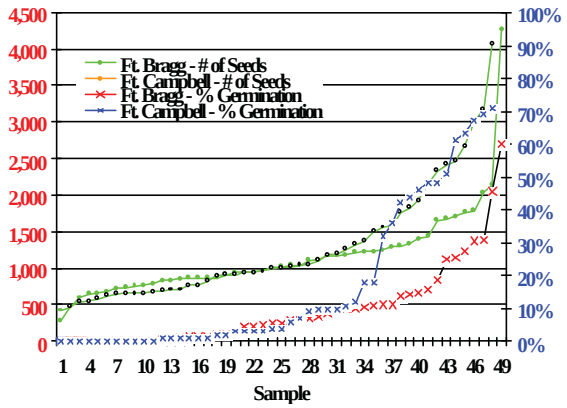

Fig. 11. India variety

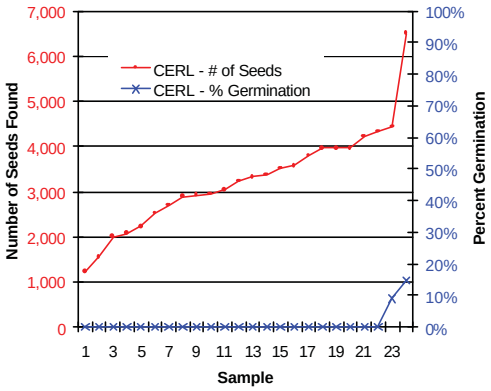

Fig. 12. Sunshine variety

Geographical Range for Vetiver Survival

As shown in Table 1, the vetiver was planted at 18 U.S. Army installations and on two private land sites. All sites are located within the mid-eastern parts of the United States. No effort was made to field-test vetiver survival in the mid-western states because of low amounts of annual rainfall. Fig. 13 overleaf illustrates the approximate range for vetiver survival in the United States.

Conclusion

Introduction of an exotic plant like vetiver on U.S. Army lands is a matter of serious concern unless it is proven that the plant will not become an invasive weed. Seed viability and germination tests have shown that vetiver does produce viable seeds that germinate under a controlled laboratory environment. However, five to seven years of field plantings of vetiver on several U.S. Army lands have demonstrated that vetiver seed does not germinate and establish plants under actual field conditions. Results have also shown that vetiver is a passive plant that does not like competition from native plant species. Thus there is little chance that it will ever invade native grasses. However, these results may not be taken as conclusive. More research is needed to determine the behaviour of the plant under more humid and warmer climatic conditions of the deep south-eastern states of the United States. In these states, how the plant will respond if planted in fertile wetlands is also uncertain. For example, Sunshine vetiver is known not to flower or produce mature seed under Louisiana conditions. However, the same plant did flower and produced mature fertile seed when planted at Champaign, IL, and Ft. Bragg, NC. Before promoting the use of vetiver in the United States, the risks associated with this plant must be carefully examined even though initial indications are that the plant is not an aggressive colonizer and simple methods are available for its control.

On erosion control effectiveness, the results have shown that vetiver can survive on infertile and sandy soils where even native plants do not grow at all. When planted early in the spring in rich fertile soils, the vetiver plants have grown over 13 feet tall and produced 17-33 healthy tillers to provide an excellent sediment filter and effective hedge against erosion.

Future Research Goals

Research is needed to develop a triploid *(2n = 2x = odd number)* to ensure seed sterility. This can be accomplished through cross-pollination between vetiver and its close relatives. Research in the United States and abroad has demonstrated that vetiver has no parallel as a bio-terrace, biological filter and hedge against erosion. The plant can survive a wide range of soil conditions. Thus it possesses excellent potential for erosion control under U.S. Army-unique environments. To be applied across the United States, the plant must be tolerant to cold winters of the North. This can be accomplished by using techniques of genetic engineering to identify and transfer cold-tolerant genes of winter hardy plants into vetiver cultivars.

Fig. 14. Vetiver plant hardiness zone map